The Yardley Fault.

By Benjamin Smith Lyman.

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1. Situation.
2. Presumptive Importance.
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4. Ocular Illusions.
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9. Width of the Fault.
10. Filling of the Fault.
11. Fault not caused by Trap.
12. Conclusions.

1. There is a fault of striking appearance in the railroad cut of the Bound Brook line of the Philadelphia and Reading Railroad nearly a mile west of Yardley Station. It is the same as the fault that was described by Prof. Henry Carvill Lewis before the Geological Section of the Academy of Natural Sciences in March, 1880, as published, with a figure, in the Academy's *Proceedings* for 1882, pp. 40 and 41.

2. The fault seemed highly important, and he remarked at the outset, "that it was not often that a section of a well-defined fault was exposed for study. Frequently a fault starts a line of erosion which obliterates all traces of it, and the actual junction of the faulted measures is either occupied by a stream or is so covered by talus that it can only be inferred from adjoining outcrops." It is quite true that a fault, great or small, must very rarely be exposed naturally; though its place is not so apt to be occupied by a stream as narrow river gorges or chasms often suggest; for they, perhaps, without exception, are merely the result of secular erosion without any fault at the outset. Faults, too, are probably not in general sudden disruptures leaving gaping abysses that may be filled by streams and afterwards widened into important valleys; but arise in small movements and increase by slow degrees through many long ages. Meanwhile the surface erosion accommodates itself gradually to the changed circumstances according to the hardness or softness of the beds that may be brought to light; and the surface wash, except possibly in rare cases on the face of a cliff, obscures the junction of the two unmatched sides of the fracture. Artificial exposures of small faults are numerous, as, for example, in the railroad cuts near Phœnixville and Gwynedd; but such exposures of great faults are necessarily rare because great faults are comparatively rare; and they must seldom be encountered in railroad work, that keeps to the surface as much as possible, though they may be found somewhat oftener in mines. The presumption, then, in the case of a fault exposed by a railroad cutting is that it is a small one, however important a look it may have.

3. The Yardley fault is so striking because a thick bed of bright red shales on the western side abuts against light brownish gray shaly and somewhat pebbly very soft sandrock on the east, with no lower

limit to the sandrock exposed and with no thick bed of red shales in the exposed section of nearly a hundred feet above. If, then, the downthrow were to the west, it would have to be more than that hundred feet, or the red shales would be found in the eastern part of the cut.

4. Certain ocular illusions give at first the impression that the downthrow is really to the west. On the north side of the railroad, where, as Prof. Lewis says, the fault is best observed, the slope of the cutting, combined with the steep inclination of the fault and its direction, makes the fault appear to rise eastward, or dip westward, as represented in his figure; and a westward dip would imply a westward downthrow. Furthermore, as he mentions and represents in his figure, the light brownish gray shaly sandrock above the red shales has, or had some years ago, the appearance of being turned up at the side of the fault, as if forced into that position by a downthrow westward. But that appearance is now less noticeable than formerly, and seems to arise from the fact that there is a slight depression, probably less now than formerly, in the side of the cutting just west of the fault. As the northwesterly dip of the beds is nearly at right angles with the direction of the railroad, the depression of itself brings the exposed edges of the layers to a lower level than at the fault, and readily gives to an observer standing on the railroad the impression that the layers just there dip away from the fault more steeply than they really do. Indeed, the southwesterly course of the railroad, a little more southerly than the strike of the rock beds, thereby rising slowly across the measures, makes his figure give the impression that the rocks dip easterly, instead of northwesterly.

5. The rock beds here dip about twelve degrees, north about twenty-seven degrees west (true meridian). The fault dips about seventy-seven degrees, north about seventy-eight degrees east; that is, with a strike of about north twelve degrees west and an easterly dip, instead of the northeasterly strike and westerly dip that the slope of the cutting is apt to make one believe at first. The accompanying plate gives a geometrical construction from those observations, carefully verified at visits several years apart, and shows the true position of the fault and the probable relation of the beds on both sides.

6. As the fault dips easterly, the downthrow is beyond a doubt in the same direction. For this is plainly not a reversed fault, longitudinal to the strike, like almost every one of the anthracite region, caused by an overthrust of sharply folded beds under strong horizontal compression; but is a normal fault, transverse to the strike and occasioned apparently by the unequal sinking of the beds into the underlying rock mass, plastic under their enormous weight. There is no reason whatever to suppose that the downthrow here is not in the direction of the dip of the fault according to the almost invariable rule of normal faults.

7. There is, then, no evidence at all that the extent of the downthrow is more than a dozen feet, and the shallowness of the cutting together

with the talus at its sides does not make it certain that the downthrow is more than half a dozen feet. The light brown soft shaly sandrock overlying the dark red shales is likely to be the lower part of the similar rock bed that they abut against at the fault; but it is not known how near the top of the dark red shales comes to the surface on the east of the fault, nor whether it may not even exist there above the level of the railroad bed, but concealed by the talus at the bottom of the cutting. As such faults are apt to be small, and as none of more than a few yards have been found among the numerous exposures of like faults in other railroad cuttings of Bucks and Montgomery counties, it is highly probable that the downthrow here is not more than about a dozen feet.

8 The rocks, therefore, west of the fault are almost wholly lower beds than those east of it; and it is not strange that they should be of different character. Those on the east are in great part light gray sandrock, weathering light brownish gray, with mustard-seed quartz grains, and much decomposed white feldspar and black grains, apparently decomposing hornblende and mica, and are in some parts very pebbly with pebbles of quartz and black metamorphic rock. The materials seem to be those of the gneiss only a mile distant to the south. The rocks west of the fault are in great part red and shaly, but in part light gray and light brown sandy shales. There is not here any marked division "between the lower white conglomerate and the overlying red shale," as suggested by Prof. Lewis; for the gray somewhat pebbly sandrock on the east of the fault belongs to much higher beds than the more decided conglomerates a few hundred yards to the south. There are many alternations of red and gray hereabouts and the change at the fault is but one of them.

9. The fault on the north side of the cut is perhaps two feet wide towards the top, but about half way down widens with irregular outline to perhaps four feet, as exposed in 1887, or to 5½ feet, as stated by Prof. Lewis in 1880. At present the loose earth, or talus, partly conceals the middle and wider portion of the fault.

10. The width of the fault is filled with loose, crumbling, mostly incoherent materials that are in the main of a very dark or blackish brown color at the widest part. Prof. Lewis took the material to be decomposed trap, and the fault to have been filled by a trap dike. On close examination, however, the material is seen to contain much quartz in small colorless grains of irregular and rounded shapes, dark mica scales, much decomposing, very soft white, and in part slightly yellowish feldspar, at least partly plagioclase and perhaps wholly so; and the dark brown portion seems to be decomposing hornblende. The constituent particles, then, are all such as are found in the neighboring gneiss and are mostly to be distinguished in the sandstone just east of the fault; and have no doubt been washed into the crevice occasioned by the fault. The occurrence of so many quartz grains is of itself proof that the material could not be decomposed trap. Besides, a trap dike would almost cer-

tainly have left at least some blocks of trap on the surface and no trap blocks are known to occur anywhere within seven miles of the fault.

11. He considers the fault to have "been caused by the pressure from below of the molten trap," and in support says that near Taylorsville he has "observed the dip of the red shales changed in the vicinity of a trap dike," a whole quadrant in direction. A more thorough investigation, however, has shown that the trap there is undoubtedly an overflow sheet conformable to the shales, and not a dike that has changed the dip of the shales. He also says that "near Harleysville a dike below the surface has metamorphosed the strata into black argillite and reversed the dip to the south." It is now known that Harleysville is near the axis of an important basin, or synclinal, somewhat closely though not steeply folded, and is on the belt of Perkasie Shales, that contain some dark and blackish beds, as well as many greenish ones, through a great length of outcrop, often several miles from any trap, and with no reason whatever to suppose the dark color to come from dikes below the surface instead of from the character of the original constituents of the shales, or to suppose the dips occasioned by the trap.

12. It is clear, then, that the Yardley fault is simply a transverse or normal fault, quite unconnected with any trap dike; that the fault dips eastwardly; that the downthrow is no doubt in the same easterly direction; that notwithstanding the conspicuousness of the fault through the contrasted colors of the rock beds, the amount of downthrow is probably no more than about a dozen feet; and that the extent of the fault along its strike is consequently not very great. As the fault is nearly at right angles with the strike of the rock beds, it would give, even if large, no great support to the old idea that the apparent thickness of the New Red might be due to a series of great faults parallel to the strike—an idea that has made the least appearance of an important fault in the New Red seem highly welcome to geologists. Such longitudinal faults are indeed generally of greater extent than transverse ones; but, as they can arise only from tremendous pressure on beds of great firmness, it is hard to imagine their occurrence in a region of such gentle dips and weak shaly beds as our New Red field.

The Chalfont Fault Rock, So Called.

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1. Situation.
2. Prof. Lewis's Description Cited.
3. The Two Photographs.
4. Southwesterly Dips in the Eastern Photograph.
5. Southwesterly Dips in the Western Photograph.
6. Southwesterly Dips Confirmed.
7. Saddle and Basin.
8. Conclusions.

1. Just east of the railroad station at Chalfont, in Bucks county, Penn-